IDENTIFICATION OF AN AEOLIAN FLAT ENVIRONMENT, WOOD COUNTY, OHIO[1]

ARTHUR LIMBIRD

Department of Geography, Bowling Green State University, Bowling Green, Ohio 43403

LIMBIRD, ARTHUR. Identification of an Aeolian Flat Environment, Wood County, Ohio. Ohio J. Sci. 75(3): 132, 1975.

Sand deposits are relatively common in northwestern Ohio. Most of these deposits have been identified as beach ridges associated with proglacial lake stages which preceeded the present Lake Erie. One area of sand deposits is located west and northwest of Bowling Green, Ohio. Some of these deposits have been attributed to the Lake Warren Stage and are recognized as former beaches. Other deposits have been labeled sandspots. These sandspots have been investigated using a random sample of test sites. At each of the chosen sites soil samples were removed from 0.35, 0.65, and 1.00 m depths and subjected to a mechanical analysis and skewness test. Strong positive skewness values indicated that the sandspots were wind deposits and probably part of an aeolian flat environment. This finding may change the concepts of the origin of some of the sand deposits in northwest Ohio.

Most of the area of Wood County in northwestern Ohio is situated on a broad, flat, glacial lake plain of the late-Wisconsin stage. The lake plain resulted from the temporary ice-dammed lakes which formed when the edge of the melting glacier occupied the eastern end of the Lake Erie Basin and halted drainage in that direction. The water level in the basin was raised up 200 feet above the present level of Lake Erie. The presence of the lake had the effect of leveling the underlying Wisconsin-age glacial till which was previously deposited in a relatively flat ground moraine and of forming low ridges of fine-grained sand above the till. These ridges were identified as beach ridges or sand bars formed in various stages of the ice-dammed lakes which preceeded Lake Erie (Forsyth, 1959). The Bowling Green area was submerged throughout the earlier, deeper lake stages, including Maumee III and Whittlesey. During the later stages when the water level dropped, the shallower lakes produced a series of parallel or near-parallel sand ridges as beaches or as offshore sand bars. It has been suggested that these features were constructed far off shore in a broad, shallow lake (Forsyth, 1966).

A number of these sand deposits have been correlated with the Lake Warren Stage and were recognized as former beaches of this lake stage. Lake Warren was formed about 12,000 years ago during a period of ice advance. The glacier front occupied a location where the eastern outlet was blocked and the lake drained west through central Michigan. The beach ridges of the Warren Stage were remarkably sandy and gravel is a rare occurrence, due to sand deposition on the ice margins (Solohub and Klovan, 1970). Sand was so abundant in western Ohio, including the Wood County area, that sand dunes may have been more common than beach ridges (Forsyth, 1959). In this part of Ohio, the lake was shallow and patches of dunes and beaches occurred in offshore sites that were often associated with low islands. As the ice retreated and the lake level lowered, the Bowling Green area emerged and some of the previous sand bars may have been blown into dunes before being stabilized by vegetation (Forsyth, 1966). The city of Bowling Green occupies one of these sand features, and a major area of sand deposits is located west and northwest of the city (Figure 1).

Ottokee and Spinks loamy, fine sands are soils which identify a number of the sand deposits west and northwest of Bowling Green (USDA, 1966). These deposits have been classified as beaches or offshore bars of proglacial Lake Warren. Many isolated sand deposits, however, were found in Wood County which are associated with glacial till soils such as the Hoytville series. These isolated sand deposits were labeled as sandspots in the soil survey and are particularly prominent in the area northwest and west of Bowling Green (USDA, 1966). The sandspots have not been attrib-

[1]Manuscript received January 28, 1975 (75–8).

uted to any particular proglacial lake stage, but are apparently deposits associated with the Lake Warren beaches and bars. Of particular interest is the origin or environment of deposition of these isolated sand deposits. If the sandspots are remnants of beaches or sand bars, then they probably should show evidence of a water-deposited origin. On the other hand, if the sandspots are windblown then they probably should show sorting and a finer texture than the recognized beaches and sandbars.

STUDIES OF BEACHES AND DUNES

Studies of sedimentology have been justified in the determination of textural parameters of recent sediments. These studies have been an aid in determining

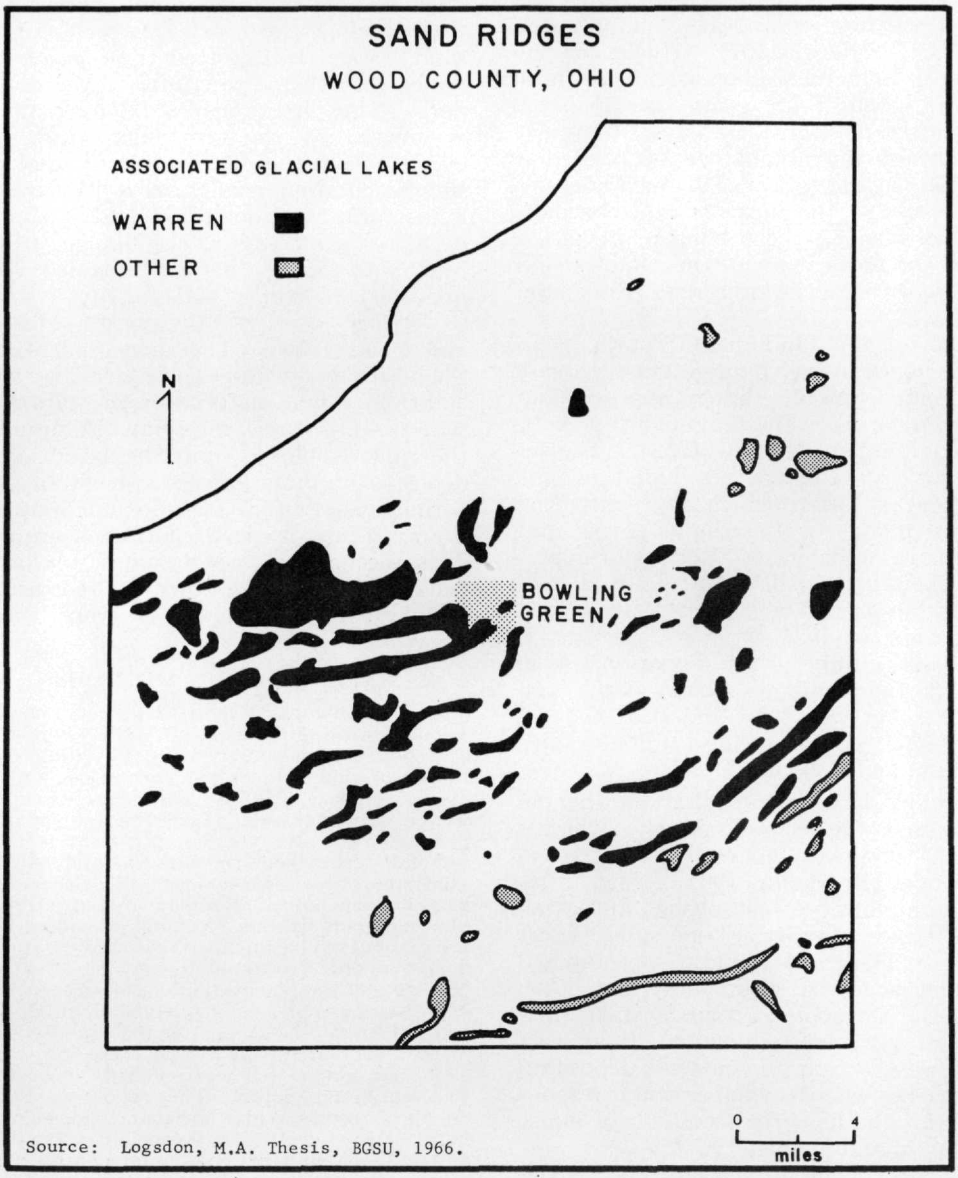

FIGURE 1. Locations of Sand Ridges, Wood County, Ohio.

depositional environments of ancient sedimentary deposits (Asseez, 1972). A number of different methods have been used to distinguish the source of sediments and/or the environment of deposition. Studies of the roundness of sand grains have shown that dune sands are more rounded than beach sands (Beal and Shepard, 1956). A measure of the volume percentage of heavy minerals shows that there are more heavy minerals in the silt fraction in dunes than in beach sands (Bradley, 1957). However, the most meaningful studies seem to be those which in effect are grain size analyses. Grain size distribution analyses represent a plot of the abundance of particular samples against grain size. Such analyses make use of the mean size of the individual samples, the sorting or deviation from the mean value of the samples, and the skewness of the grain sizes (Friedman, 1961).

One of the fundamental purposes in studying sediment parameters is to ease the comparison of sediment analyses, and to help correlate the sediment type with its environment (Inman, 1952). The descriptive parameters are based on the phi (ϕ) notation which represents the negative $\log_2$ of the diameter of sand grains in millimeters. Results of applying the standard deviation in studies of sand samples have shown that with a deviation of 0.21 to 0.26 the site is probably a dune, if the deviation is 0.30 to 0.35 the site is probably a beach, and if it is between 0.26 and 0.30 the depositional environment is not known (Mason and Folk, 1958).

Studies have shown that on the phi scale dunes are generally positive, whereas beach sands are generally negative in skewness (Friedman, 1961). Such a relationship has been established in coastal, lake, river, barrier island, and desert dunes. Dune sands tend to be composed of finer sand size sediments than beach sands and usually contain a small mixture of silt sized sediments. It appears that wave action prevents silt deposition in beaches whereas wind action is responsible for the higher silt content of dunes (Shepard and Young, 1961).

The use of the phi measures is a recognized standard of descriptive measures for grain size distribution. These measures are approximately equal to moment measures used in mathematical statistics. The measures are computed from five percentile sand size diameters (5, 16, 50, 84, 95 percent) which are obtained from the cumulative frequency curve of the sample being examined (Inman, 1952).

In attempting to recreate the mechanism of beach and dune formation, one must assume that wave and current action develops the beach area first. The sand is then transported from beach to dunes and then from dunes to aeolian flats. The direction of sand movement is favored by the prevailing wind. A coarse tail in the distribution of sand in the beach area results in a somewhat higher standard deviation and a slight negative skewness. The change from beach to dune is accompanied by improved sorting and abrupt shift to strong positive skewness (Mason and Folk, 1958). The development of the positive skewness can be either by the addition of fine material or the subtraction of the coarse material. Assuming the sand is blown from the beach and deposited in dunes, the coarse end of the normal distribution lags behind because the wind cannot carry the coarser grains. This mechanism was assumed to have been operative in the Bowling Green area, if, in fact, the sandspots were wind blown.

MATERIALS AND METHODS

A study area was delineated west and northwest of Bowling Green in an area where the sandspots are concentrated (fig. 1). Field collection of sand samples was carried out during the late spring of 1973. The collection sites were chosen at random among the "sandspots" plotted on the county soil map (fig. 2). Other samples were taken from known sand bar or sand ridge deposits for comparison. Sand samples also were collected from an area of actively blowing sands at Oak Openings Metropolitan Park, about twelve miles northwest of the study area. In order to avoid the mixing effect of plowing and the potential effect of recent wind deposition, samples were selected from 35, 65, and 100 cm depths at each of ten "sandspots" in the study area. In five of these locations clay loam glacial till was reached before the 100 centimeter depth. The sandspots have circular or semi-circular horizontal dimensions, little, if any, vertical development. Samples at the 35, 65, and 100 centimeter depths were taken from seven sand bar or sand ridge locations from within the study area. Samples were taken from the surface at five points in the actively blowing sand site at Oak Openings outside the study area for a total of 49 samples.

Each of the samples was air dried to remove the moisture, weighed, and then placed in the uppermost of a series of sieves. The nest of sieves was shaken in a mechanical shaker, and the portion of the sample collected in each sieve was weighed. The sieves were chosen to duplicate the one-half phi intervals advocated in previous studies (Solohub and Klovan, 1970).

Through the mechanical analysis process a cumulative frequency distribution of grain size was constructed for each sample. The mean, median, phi deviation, and phi skewness were then calculated for each sand sample. King (1973) suggested the application of the skewness test to help determine the origin of the sandspots. The skewness value was utilized as the primary measure in evaluating the depositional environment of each individual sample. A negative skewness value was taken to indicate that the sample was from a beach or other water-born deposit, whereas a positive skew-

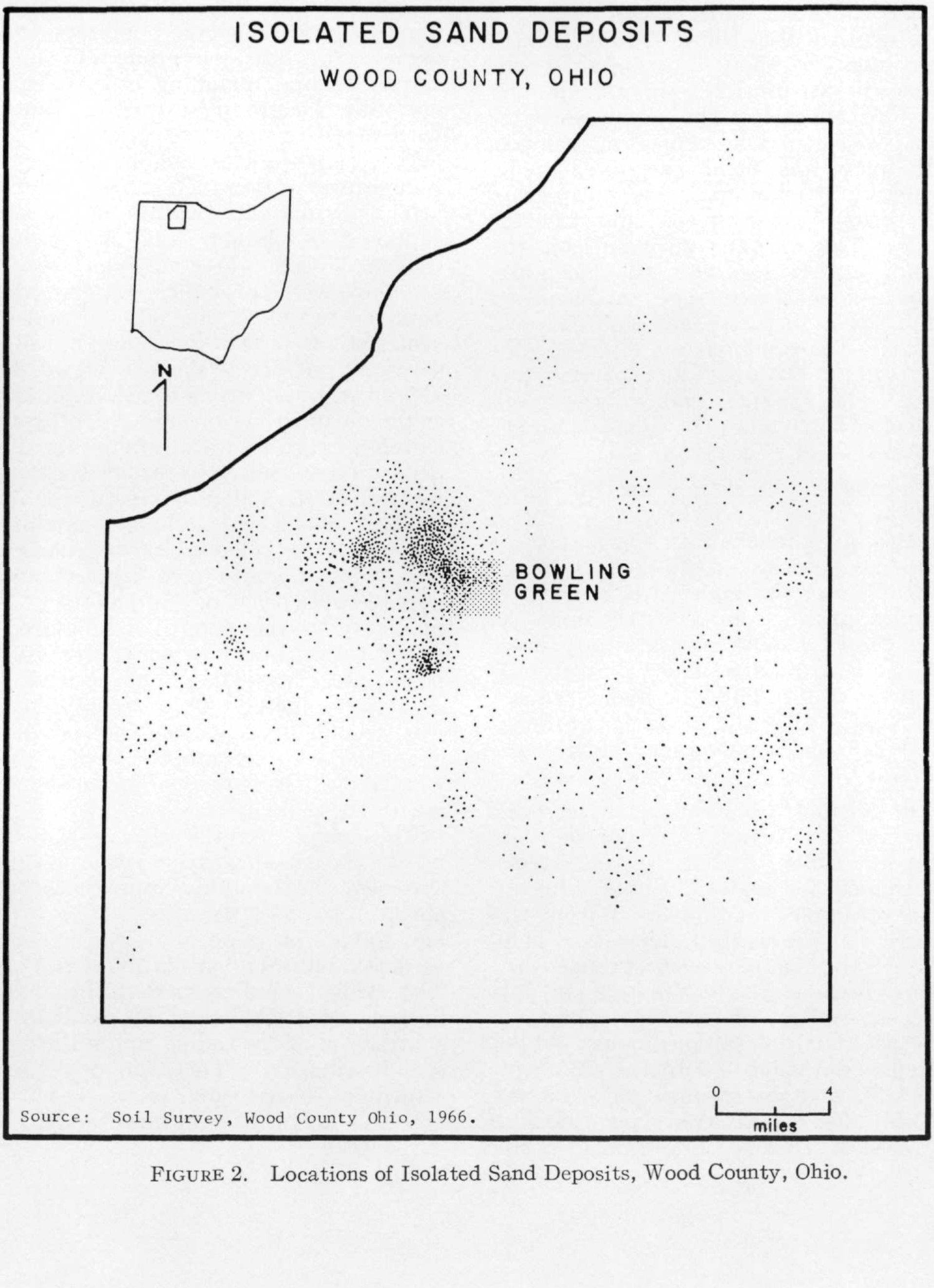

FIGURE 2. Locations of Isolated Sand Deposits, Wood County, Ohio.

ness value indicated that the sample was from a dune or other windblown deposit (Chappell, 1967).

RESULTS

Twenty-four samples were taken from the "sandspots" of the study area. Ten samples were from the 35 centimeter depth, nine were from the 65 centimeter depth, and five were from the 100 centimeter depth. There was no apparent difference in the grain-size distribution with depth within the individual sample sites, nor was there any apparent difference in distribution from one sampling point to another. The skewness value was positive in all twenty-four samples and there was little variation among samples in median grain size, mean grain size, deviation in grain size, and skewness value. The median phi value for the "sandspots" was +2.63, the mean phi value +2.84, the average phi deviation 0.259, and the average phi skewness +0.28. The predominant grain size for the "sandspots" was a fine to very fine sand. The skewness value agrees well with skewness values for dunes in studies by Mason and Folk (1958).

Calculated phi values for the sandspots were similar to phi values for five sand samples taken from the surface of dune-like deposits at the Oak Openings Park. There was little variation among samples taken from Oak Openings as with the sandspots of the study area. The average median phi value at Oak Openings was +2.58, the average mean phi value +2.72, the average phi deviation 0.215, and the average phi skewness +0.27.

The calculated phi values for the seven supposed beach and sand bar deposits were more diverse than the phi values determined for the sandspots. In all, twenty samples were secured from the apparent water-worked deposits. Thirteen of the samples were grouped together because the calculated phi values were similar. The median phi value for the thirteen samples was +1.30, the mean phi value +0.97, the phi deviation 0.37, and the average phi skewness −0.18. The negative phi skewness value for these thirteen beach and bar deposits compares favorably with the negative skewness values for beaches in Mason and Folk's studies (1958).

The other seven samples taken from supposed water-worked deposits do not show similar phi values to those discussed above. Two samples taken from the 35 centimeter depth have phi values similar to the sandspots with an average phi skewness of +0.22. Five samples taken from the various depths of two apparently water-worked deposits do not seem to fit into the group of samples similar to and including the sandspots, nor into the group of thirteen samples with a strong negative skewness. The average phi skewness value for the five samples was +0.08.

The calculated phi values for the seven supposed beach and sand bar deposits indicated that three of the deposits sampled were probably water-worked. Samples tested at the 35, 65, and 100 centimeter depths in these deposits all are decidedly negatively skewed. Two other deposits showed strong negative skewness at the 65 and 100 centimeter depths indicating a probable water environment for deposition. The 35 centimeter samples from these two deposits, however, had positive phi skewness values similar to the sandspots. These two locations appear to have wind-blown deposits superimposed over beach or bar deposits. The final two deposits could not be placed in either a wind-blown or water-worked deposit category. The slight positive phi skewness value (+0.08) of these deposits was inconclusive as to the origin of depositional environment. Perhaps both wind and water worked simultaneously to create these deposits.

The change from the negative skewness of the beach deposits to the positive skewness of the dunes apparently was abrupt. In the deposits where windblown material appears to overlie water-worked material no gradation was found. The evidence indicates that the change in skewness is probably the result of the subtraction of the coarse end of the grain size distribution. The change was from a medium, coarse sand in the beach deposits to a fine to very fine sand in the "sandspots."

CONCLUSIONS

An attempt can be made to reconstruct the depositional environment of the Bowling Green area sandspots. In the area northwest and west of Bowling Green in Wood County, the sandridges are located generally south and southwest of the concentrated area of sandspots (fig. 1). The sandspots occupy an area which seems to be a former off-shore location northeast of recognized beaches and bars (fig. 2). Assuming similar wind conditions as today, with prevailing southwest winds, sands probably were blown into the small dune-like deposits of the recently exposed lake bottom after the water receded. Thus giving the impression that the sandspots may have been part of a series of offshore sand bars (Forsyth, 1966).

The sandspots seem to closely resemble an aeolian flat feature as described in previous studies by Mason and Folk (1958). The area is almost level and generally featureless with occasional patches of low dunes. The prevailing southwest wind apparently reworked some of the beaches and then moved sand across the surface of the beach ridges, depositing windblown material over the previously established beaches. Such sand movement may explain the positively skewed (fine grained) deposits overlying the negatively skewed (coarse grained) deposits in some of the sample locations on the supposed beaches. When the dominant wind blows offshore, as in the study area, the beach may inherit the character of backshore dunes.

Continued wind movement would have been necessary to carry the sand toward the northeast into the nearly level mud flat of the recently exposed lake bottom. Variable winds from other directions would build the sandspots into somewhat circular and slightly convex shapes in the aeolian flat environment. It should be understood that reconstruction of the depositional environment of the sandspots is somewhat speculative. This study however, does show that wind has been a major factor in the development of sand deposits over much of northwestern Ohio. Wind probably was the prime factor in the creation of the sandspots and has contributed to the rearrangement of some beaches and sand bars. A more complete investigation of all of the sand deposits must be undertaken in order to fully understand the origins of these deposits and the depositional environments of the area.

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